



Standard Test Method for Thermoelectric Power of Electrical-Resistance Alloys¹

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1. Scope

1.1 This test method covers the determination of the thermoelectric power of a metal or alloy with respect to copper when the temperatures of the junctions lie between 0 and 100°C.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to become familiar with all hazards including those identified in the appropriate Material Safety Data Sheet (MSDS) for this product/material as provided by the manufacturer, to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*²

B3 Specification for Soft or Annealed Copper Wire

3. Terminology

3.1 *thermoelectric power, Q, n*—the electromotive force in an electric circuit consisting of two metals when the junctions between them have a difference in temperature of 1°C.

3.1.1 *Discussion*—Experimentally, it has been found that the thermoelectric power of two metals is not a constant but depends on the mean temperature of the junctions. However, over a range of temperature from 0 to 100°C it is usually sufficient to assume that the thermoelectric power is independent of temperature so that for this range of temperature:

$$Q = E(t' - t)$$

¹ This test method is under the jurisdiction of ASTM Committee B02 on Nonferrous Metals and Alloys and is the direct responsibility of Subcommittee B02.10 on Thermostat Metals and Electrical Resistance Heating Materials.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

where:

E = the electromotive force developed in the circuit,

t' = the higher temperature at one junction, °C, and

t = the lower temperature at the other junction, °C.

4. Significance and Use

4.1 The purpose of this method is to determine the suitability of different metals for use in resistance apparatus in which a low thermoelectric power is desired. As most electric circuits are largely composed of copper, the thermoelectric power of a resistance metal will generally be measured against copper.

5. Test Specimen

5.1 The metal or alloy to be tested shall be in the form of sheet, ribbon, or wire and the test specimen shall be of such length that the two ends can be readily maintained at different temperatures. At each end of the specimen a copper lead of convenient size shall be fastened. These leads shall make good electrical contact with the specimen, such as that obtained by welding, brazing, or soldering. Slight impurities in the copper have a negligible effect on the thermoelectric power.

NOTE 1—When necessary to specify the quality of the copper leads, reference should be made to Specification B3.

6. Procedure

6.1 *Measurement of Temperature*—As a matter of precaution, the average temperature used in determining the thermoelectric power shall be approximately the same as that to which the material will be subjected in practice, and in no case shall the temperature difference between the two junctions be less than 20°C. The temperature at each of two junctions shall be measured by a device that is sufficiently accurate to determine the temperature difference within 5 %. A convenient method for determining the temperatures of the junctions is to immerse each junction in separate oil baths maintained at the desired temperatures. Baths that are stirred and the temperatures of which are thermostatically controlled are to be preferred. However, beakers of oil which are supported by blocks of metal, sand baths, or other means may be used, provided the thermal capacity of these assemblies is such that when the heat is cut off their temperatures will decrease at rates less than 0.2°C/min. The temperature of the oil in each bath may be determined by a calibrated temperature measuring

device of suitable precision and accuracy. If the oil is not stirred, the junctions shall be placed in close proximity to the temperature-measuring instrument. To ensure that the temperatures of the junctions shall not be influenced by heat of conduction along the specimen, the length of each specimen from the junction to the point where it leaves the surface of the oil shall not be less than 10 times the minimum cross-section dimension of the resistance material, nor less than 100 times the minimum cross section of the copper leads, and in no case less than 2 in. (50.8 mm).

6.2 *Measurement of Electromotive Force*—The electromotive force shall be determined by a method that will give the value correct within 5 %. Three different methods of measuring the electromotive force are in common use, namely:

6.2.1 The method in which a potentiometer is used to compare the unknown emf with that of a standard cell.

6.2.2 The method in which the unknown emf is equated to the difference of potential between the terminals of a standard resistor when a measured current flows through it.

6.2.3 The method in which the emf is measured by the deflection of a suitable measuring instrument.

6.2.4 In any case, precautions shall be taken to ensure that there are no parasitic electromotive forces in the measuring circuit, a condition which may be determined by placing both junctions in the same beaker, in which case no appreciable electromotive force shall be indicated.

7. Polarity of the Metal

7.1 The metal or alloy tested shall be considered to have positive polarity when, in a circuit consisting of copper and the

metal or alloy, the direction of current flow in the metal or alloy is from the junction having the higher temperature to the one having the lower temperature.

8. Report

8.1 The report shall include the following:

8.1.1 The character of the metal or alloy tested and the identification of the specimen,

8.1.2 The size, shape, and length of the specimen,

8.1.3 Method of determining the temperatures of the junctions,

8.1.4 The temperature at each junction in degree Celsius,

8.1.5 The type of apparatus used in measuring the electromotive force,

8.1.6 The observed electromotive force,

8.1.7 The thermoelectric power, and

8.1.8 The polarity of the metal or alloy tested.

9. Precision and Bias

9.1 The reproducibility of the test results depends on the control used in making the connections and the control of temperatures at the junctions. The bias will depend on the parameters listed for reproducibility and instrumentation used to measure emf.

9.2 The precision of this test method should be 1 % or less.

9.3 The bias of this test method is within 6 %.

10. Keywords

10.1 copper; electrical resistant alloys; potentiometer; thermoelectric power

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